S102PRP/S510 MODULE 1 INTO SCIENCE

MODULE 1 GETTING STARTED

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4.1

STUDY GUIDE

This course is called *Into Science*. It aims to introduce you to the basic skills and ideas that will help you with later courses—with the *Science Foundation Course* in particular. *Into Science* consists of twelve Modules that together span a total of ten weeks of study. These are described further in Section 2.

The goal of this first Module is exactly what its title suggests—to get you started on the course. More specifically, it has three main aims. These are:

- to tell you about the structure of the course
- to suggest ways in which you can tackle each Module in a reasonable amount of time
- to introduce you to some of the skills that you need to study science.

You should aim to complete this Module within one week; you will need to spend about three hours on it altogether. Exactly how long you take will depend on your background, your natural speed of working, how much of a perfectionist you are and your skill in tackling this kind of distance-teaching text. This skill, hence your speed of working, will quickly develop with practice. Section 2 lists the approximate study times for each Module in the course.

This Module, like all the others, begins with what is called a 'Study Guide'. The Study Guide is a short section that tells you in a few paragraphs what lies ahead: how long the Module should take, whether there are any experiments and whether you need to collect together any special equipment. It will also tell you what the Module is about and how you might tackle it.

You already know the broad aims of this Module (the three 'bulleted' points above) and that it should take you about three hours to complete. In addition:

1 Section 2 tells you a little more about the course, Section 3 introduces the idea of planning your time and organizing your work and Sections 4 and 5 discuss some approaches to studying. You should find that none of these sections is long or very demanding.

2 Sections 5, 6, 7 and 8 introduce several basic skills. These are:

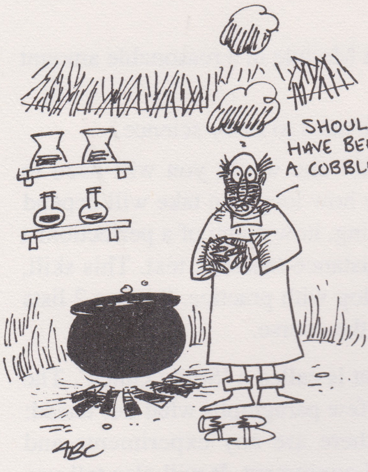
- studying printed text (Section 5)
- using a calculator and doing basic arithmetic (Section 6)
- understanding and being able to use decimals (Section 7)
- understanding and being able to use negative numbers (Section 8).

These four sections together should take you between two and three hours to complete.

3 Finally, there are no experiments in this Module—so you do not need to assemble any bits and pieces. All you need to get started is this text, some paper and a pen or pencil. To do Sections 6, 7 and 8 you need a calculator. If you do not yet own one, read through Section 6 *before* making a purchase. You can do the earlier sections without a calculator, so do not let shopping for a suitable one delay your study of the Module.

1 THE EXCITEMENT AND IMPORTANCE OF SCIENCE

Why are *you* doing this course? You might answer that you want to make an effective start to studying science, to become skilful in some areas, and to become knowledgeable about some topics. However, you may have more far-reaching goals—as have other scientists in the past. So, what is it that motivates people to learn science?



What is it that motivates people to learn science?

One factor is scientific curiosity about such questions as: why is the sky blue? Why does ice float? How do swallows navigate from here to North Africa? This tireless quest for knowledge about our world and, indeed, the whole Universe, seems to be characteristic of human behaviour. We want to know something because it is there to be known. From the shadowy origins of science, five or six hundred years before Christ, to the goal of the Human Genome Project (to have mapped and identified, by the year 2006, all 100 000 genes that influence the characteristics of humankind) has been a route march indeed. And, as humans have been in existence for at least 50 000 years, maybe 200 000 years and perhaps longer still (the subject of human evolution is a controversial one!), there is little reason to suppose that the accumulation of knowledge will cease. Whatever the risks and difficulties that arise from *knowing* (the word 'science' comes from the Latin *scio*: 'I know'), it seems that humans are unable to resist the lure of curiosity.

Another powerful reason for knowing about science—and its close cousin, technology—is simply that of wanting to be well-informed about things that matter to society. The newspaper article in Section 5 of this Module provides several examples of the interaction, for good and ill, of science and society. Where would you put *your* vote on the matter of building either coal-fired or nuclear power stations? There is no straightforward answer to that—and to even attempt an answer that is validly based on fact rather than emotion requires a *lot* of scientific knowledge.

If science has much to answer for—for example, in the creation of nuclear weapons and in facilitating the development of technologies that have created the problems of atmospheric and water pollution—it has also been beneficial in other ways. Without science, and the medical, public health, industrial and agricultural technologies arising from it, the kind of population growth that has occurred on Earth this last century would not have happened. Compare the sizes of world population given in Table 1 in order to appreciate this point.

TABLE 1 Size of world population at given periods of history

Date	Population size (estimated)
14000 BC	3 million
1600 AD	350 million
1800 AD	1 000 million
1990 AD	5 500 million

From around three million inhabitants, the population has grown to 5.5 thousand million (5 500 000 000). Note from the figures in Table 1 that the largest increase in the world's population has occurred during the last 190 years, in fact during the shortest time-span given in the Table.

The point of introducing these figures is to hint at what science has *contributed*—and what science *will have to contribute* to provide solutions to the problem of keeping perhaps twice as many of us alive in fifty years from now. Unless science contributes massively to the problems of energy supply, of food production, of the psychology of living at high population densities, of the control of pollution, of assessing and adjusting to the warming of the climate, then the future looks bleak. In contrast, if science and technology can help to solve these problems, the future may be assured.

2 THE COURSE

This Course consists of twelve Modules, and a Workbook. Table 2 lists the titles of the twelve Modules, the week in which each should be studied, and how many hours you should aim to set aside each week for study. We have given you this information to help you to plan ahead. Note that the estimated study time that you will need to set aside each week increases gradually over the course.

TABLE 2 The *Into Science* course.

Module		Week number	Estimated study time
1	Getting started	1	≈ 3 hours
2	Observing and measuring	2	≈ 3 hours
3	Looking at buildings	3	≈ 4 hours
4	The size of things	4	≈ 4 hours
5/6	Food and drink: a chemical story	5/6	≈ 10 hours
7	Living material	7	≈ 6 hours
8	Energy	8	≈ 8 hours
9	Navigating around	9	≈ 6 hours
10	Surveying	9	≈ 6 hours
11	Good writing in science	10	≈ 6 hours
12	Fossil fuels and climate change	10	≈ 6 hours

Notes:

(i) Note that the sign '≈' means 'approximately'. These study times are estimates only.

(ii) We recommend that you try completing Modules 9 and 10 in week 9, and Modules 11 and 12 in week 10. This will give a work load of 12 hours per week (or slightly more). In this way you will experience the time necessary to study a *Science Foundation Course* Unit.

Look at the titles of each Module given in Table 2. Each Module contains its own set of scientific facts and ideas, and items introduced in earlier Modules are built upon in later ones. For example, Module 7—which introduces some biology—depends on the chemical ideas introduced in Modules 5 and 6. Module 8, which looks at the conversions of energy from one form to another, depends crucially on the science contained in earlier Modules.

One of the aims of *Into Science* is to introduce you to the mathematics that you will need to study the *Science Foundation Course*. Many students are often concerned about maths, so the Modules of this course approach it in a gentle and interesting way. Although there is some mathematics (usually linked to science) in all the Modules, there is rather more in Modules 9 and 10 than elsewhere. Module 11 deals with the skill of *writing* good science, and Module 12 applies many scientific ideas developed earlier in the course to the topical issue of the use of fossil fuels and climate change.

Though we hope you will enjoy knowing some of the concepts of science described in the course—for example, about space and time, atoms and molecules, cells and organisms and so on—a major goal of each Module is to provide opportunities for you *to learn particular skills*. Science depends on observing, measuring, describing, calculating and explaining ideas to others—together with a host of other important skills. To use an everyday analogy, knowing what a pizza is and what it's made of is one thing (the facts of the matter); to be able to read the recipe, weigh the flour and use the oven is something else (the necessary skills to succeed). By the end of the course—in terms of calculating, reading effectively, writing clearly, understanding graphs, organizing experiments and so on—your range of skills and your fluency in them should be much increased.

Towards the end of each Module, you will find a section called 'Overview' which *first* lists the main scientific facts and ideas that have been introduced and *then* the skills that you have met in that Module. In the main text some items are emboldened; these are key terms. Appendix 1, which is called *Explanation of terms used*, gives a brief explanation of all these **bold** terms introduced in the Module. In short, it is a glossary for the Module.

The Workbook is a collection of additional questions that you can use at any point in the course. The study guide at the front of the Workbook provides more detailed information about its use.

3 ORGANISING YOUR WORK

It is so much easier to acquire all the other skills if you become proficient at the most basic one of all—organizing your work! Some of the points raised in the list below may seem rather obvious but they are nevertheless worth thinking about carefully.

- **Where will you work?** Try to find a regular working space that you like, somewhere that is physically comfortable. You will need enough space for the texts, your paper, file or notebook, a selection of pens, highlighters, etc. Having somewhere of your own to work makes good quality studying easier.

- **How much noise do you like when you are working?** Many people need silence, or at least a low level of background noise, in order to concentrate. You may find, however, that you study best if music is playing in the background. Try to discover the conditions that suit you best.

- **What is your concentration span?** You also need to find out the length of time you can concentrate on a piece of work before taking a break. For some this may be twenty minutes; for a few, as much as one hour.

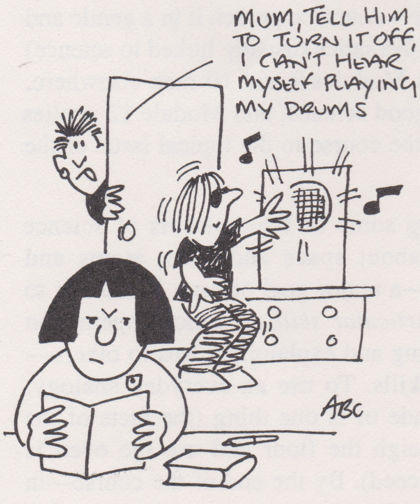
- **Where will you file your study materials?** Try to avoid losing your 'working tools' between one work session and the next. Put highlighting pens away in the same place each time. *File* those excellent notes or calculations—don't lose them! A notebook may be safer than file paper.

- **How will you keep up to date with the course?** When you start working, set yourself a target. To say to yourself 'I will read Section 4 and do all the questions in it before I stop tonight' is more productive than thinking 'I'll do a bit of the science course this evening'. Do, however, set yourself *realistic* goals; you will only disappoint yourself if you don't.

  You may find it useful to check how long you are spending on each Module by keeping a study diary. This will enable you to measure your progress and to see where you are having difficulties. It will also show you if you are being too much of a perfectionist. When the Study Guide advises a study time of three hours, this means three hours of actual reading, thinking and writing—not time taken getting ready to work!

- **Are you a procrastinator?** Often the hardest task when following a course of study is actually sitting down and opening the book or Module. Don't say to yourself: 'I'll start tomorrow' or 'I'm too tired today.' Set yourself a time that you can devote to study and open your text. Once you have done that, the rest of the task is relatively easy!

- **When can you find time to study?** Most important, you need to think about *when* you can find the time for study—6 hours is equivalent to two very full evenings' work, or working for one evening and the whole of Saturday morning. Solving this problem now should make it slightly easier to find the 12 hours or so per week that you will need for studying the *Science Foundation Course*.



Try to discover the sound conditions that suit you best.

How much attention did you *really* give the list above? Did you just let the sentences 'trickle in front of your eyes' with no real attempt to grab the meaning out of them? Or did you engage with the material being discussed and actively interact with it? Try doing Exercise 1, now.

EXERCISE 1

Read through the bulleted list above again. This time *write down* a few words in the wide margin of the text giving your personal answer to each question. Be honest with yourself—and as realistic as you can be.

You will find comments on this exercise (and others) at the back of the Module.

As a result of doing Exercise 1, you may have measurably improved the way you will tackle this course. A second benefit is that you may have noticed how *active* involvement with the text—writing things down in this case—keeps you alert and helps you achieve and remember more.

4 APPROACHES TO STUDYING: GETTING AN IDEA OF THE TASK

Imagine you are beginning an evening study session with a new Module on the table in front of you. It may be twenty five pages long, perhaps forty or more. What do you do? How do you get to grips with it in the first instance—and how will you get all the way through it in the coming few days? How can you expect to remember whatever it is you need to remember? And if there were an exam in a few months (there isn't!), how would you be able to revise the key points?

The good news is that you are *not* required solemnly to read every line or every paragraph with equal thoroughness. Sometimes, where you are already familiar with a topic, you can rush through the text. For example, you may already have excellent study skills—in which case much of Sections 3 to 5 of this Module should take up little of your time. Alternatively, you may spend your working life using a calculator; if you do, omit Section 6. In other parts, where the material is new or seems difficult, you will need to read it thoughtfully and carefully. For example, you may *never* have been happy with decimals in the past—and you may decide that (whatever the official advice about time) you will work at Section 7 until you finally feel at ease with them.

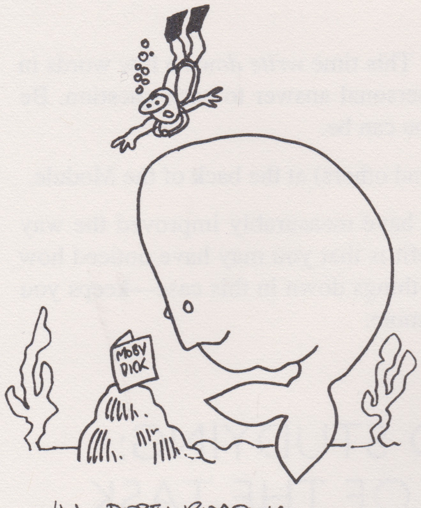
So, how are you to decide what to work on and what to read very quickly? One effective way is to look at the contents list at the front of a text (and the *Overview* at the end) and then turn to the pages of any sections you feel you *could possibly* give less time to. Based on what you see there—and on your attempts at one or two 'self test' questions in those pages—you should make a preliminary judgement about which parts can be worked through quickly. Conversely, you may notice that some parts seem hard or totally new and you may decide to spend more time on these. Once you have decided your priorities and seen the size of the problem, you can 'begin your assault' on the Module.

EXERCISE 2

If you haven't already done so, assess the remainder of this Module in this way. What parts will you read over quickly? And what, in contrast, will you need to study slowly and carefully?

5 APPROACHES TO STUDYING: HOW TO READ TEXT

After the kind of survey involved in Exercise 2, you will be aware that some sections can be skimmed at high speed, while others will need reading in depth with painstaking attention. But how do you actually succeed with the latter?



Some tactics that work have already been introduced. As a result of Section 3, you may have discovered that 30 minutes is your natural concentration span, and that a background of pop music actually helps! You also have an idea from Exercise 1 that *doing things* with the text is often better than just reading it. Try reinforcing this idea of *active reading* by doing Exercise 3.

EXERCISE 3

Re-read Section 1 of this Module. Note down in the margin of the text the reasons that were given for people wanting to learn about science. Take about 5 to 10 minutes over this and then compare your points with our list at the back of the Module.

Just as with Exercise 2, you had a pen or pencil in your hand as you re-read Section 1. Making your own notes forced you to think carefully about the text and to extract the essential points.

The subject matter in Exercise 3 was straightforward. But even if it had been more complicated—how an electric motor works, for example—the technique of *making your own personal notes* from the text would work just as well. You would stay alert while reading, you would understand what you were reading about, and the notes would be available for you to revise from at a later date.

Making notes in the margin is just one kind of active reading. The following lists some other useful ways of interacting with text.

(1) If the text has questions included within it, do them. The same applies to any other exercises and activities.

(2) If there are no questions printed in the text, set your own questions. The key ones to ask yourself are: '*What* is this section all about?' 'What *is* it telling me?'

(3) As an alternative to making marginal notes (or perhaps in addition to such notes) use a coloured *highlighting* pen to mark the key phrases in a paragraph.

(4) As well as marking or writing on the text itself, you could write down important words or phrases on paper or on index cards.

(5) Make a summary (a précis) of noteworthy pages. This involves contracting a page to three or four lines. Making a précis is quite an art. Later Modules will return to it.

(6) If the text reminds you of any experiences you have had, or information that you have already come across, make a note in the margin.

(7) Refer to all the diagrams in a Module and look at them carefully. Looking at diagrams is a different activity from reading and keeps you alert. Sometimes you may want to make your own version of a drawing.

(8) Carry out all of the mathematical activities. Once again, this provides you with a break from reading.

(9) Think carefully about what the text is trying to say, and you will find it easier to follow the discussion (or argument or description).

The first point in the list referred to various activities. Each Module has two types of question that you can use to test your understanding of items covered in the text. *Self Assessment Questions* (SAQs) are designed to help you judge how well you have understood the concepts presented, or to give you practice in a skill you have just learned. You will find SAQs most valuable if you make a serious attempt at each one before looking up the answers. Here is an example. The answer to SAQ 1, as for all SAQs in all Modules, is to be found at the back.

SAQ 1 Of the nine suggestions for working actively with a Module listed above, how many involve having some kind of pen or pencil in your hand as you work on the Module?

The second type of question, an in-text question (ITQ), looks like this:

□ Where is the answer to this question?

■ In the line immediately following.

These questions are unnumbered, and are designed to help you progress to the next step. They should make you stop and think about what you are reading, and you can use them to reassure yourself that you are following the argument. It is good study practice to cover up the text with a piece of paper, sliding it downwards as you read, so that you are not tempted to read the answers before formulating your own!

Let's conclude this section with one more exercise in active reading. Exercise 4 refers to the newspaper article 'Grim prophecy of ruinous famine for overloaded Earth'. This was taken from the *Daily Telegraph*, August 27 1991. As every passing year brings fresh concern about the environment, the article remains very topical.

Grim prophecy of ruinous famine for overloaded Earth

Reports by Roger Highfield, Science Editor, and Adrian Berry

PROSPECTS are bleak for a global agreement to deal with the effect of growing world population and changing climate, the annual meeting of the British Association for the Advancement of Science was told yesterday.

Sir Crispin Tickell, who is credited with turning Mrs Thatcher "green" and now advises Mr Major, said an international conference next year was unlikely to reach an agreement.

He predicted that the United States would be more obstructive than Third World countries, which find it difficult to meet emission targets and improve their living standards.

In a doom-laden speech at the start of the meeting in Plymouth warning of creeping famine, disease and breakdown, Sir Crispin said: "In relation to the size and the scope of the issues, we have hardly started to cope with them. We are still at the beginning of the beginning."

He added: "Conflict, famine, disease and breakdown are not uncommon in history and could creep upon us as they have crept on others, lurching from crisis to crisis until, together, they become unmanageable."

Although it was too late to avert or prevent over-population, the depletion of resources, environmental degradation, industrial pollution, global warming and ozone depletion, it was still possible to mitigate some of their effects.

The big test comes next year at the Earth Summit, the United Nations Conference on Environment and Development.

Sir Crispin, former British ambassador to the UN and now warden of Green College, Oxford, said delegates to the conference would have to tackle "problems more difficult even than those created by the introduction of nuclear energy and weaponry 40 years ago".

The world's population had grown from two billion in 1930 to 5.3 billion now and would be more than eight billion in 2025.

It was doubtful whether this number could be fed, Sir Crispin said, explaining how the amount of food available depended on how much plant matter was converted into animal protein.

If we were all vegetarians and shared our food equally, the world could support six billion, he said. But if one-third of our calories came from animal products, as in North America today, then it would only be able to sustain 2.5 billion.

Even if improvements in food supply were put into place, the prospect of such a population rise was alarming. Sir Crispin said: "Even allowing for war, famine and disease, the rate of increase—at present some 90 million more people every year—suggests that we are on the back of a tiger."

By 1989 there were around 14.5 refugees in the world. But with the population rising to eight billion or more, the refugee rate "could rise disproportionately, with alarming consequences for the integrity of human society."

Biodiversity, or the variety of life, was under heavy and sustained assault, he said. He likened the effect of losing species to removing rivets from the structure of a boat.

He said: "We can remove one, two or 10 rivets without apparent damage. But at a certain point—it could be the 11th or the 1,000th rivet—we cause the timbers to fall apart."

Sir Crispin also highlighted the North-South divide. In 1880, the ratio of real per capita income between Europe and India and China was 2:1. It is now 70:1.

"By any reckoning, the industrial countries are directly and indirectly, and however unwittingly, responsible for most of the environmental mess," he said. "Any forward look compels the conclusion that we cannot continue as we are."

EXERCISE 4

Look at the newspaper article on the previous page. In order to read the article actively, you could try any appropriate technique from the list on page 6, highlighting, making a précis and so on.

(i) By whatever method you choose, note down what you consider to be the three most important points in the article. Write no more than half a dozen or so words for each point.

(ii) There is one fairly obvious numerical error in the article. Can you find it?

(iii) Note that the article refers to a **billion**. Nowadays—in the UK, the rest of the EC and in the US—a billion is 'one thousand million'. In figures this is 1 000 000 000. Note also that the old-fashioned English billion, being one million million, is no longer in use.

6 BUYING AND USING A CALCULATOR

Both the study and practice of science depend on calculating almost as much as reading. The remaining sections in Module 1 focus on this important area.

Students who use phrases such as 'do not like', 'very concerned' or 'terrified' when faced with the thought of mathematics usually know more and can do more than they realize. If you are worried about your mathematical ability, take heart: you only need to be able to count and to know what the words adding, subtracting, multiplying and dividing mean. All the rest is taught in this and later Modules.

You may possibly have been unsuccessful in your past efforts at these areas of maths; you may have used different words (for example, 'times' for multiply, 'take' for subtract or 'share' for divide). Whatever your record, of success or otherwise, please note that from now on, all your actual calculations will be correct *because you will use a calculator*. Using a calculator is not cheating. It simply takes the pain out of doing arithmetic. You still need to know which keys to press and what the answer means—and that is a different kind of mathematical skill!

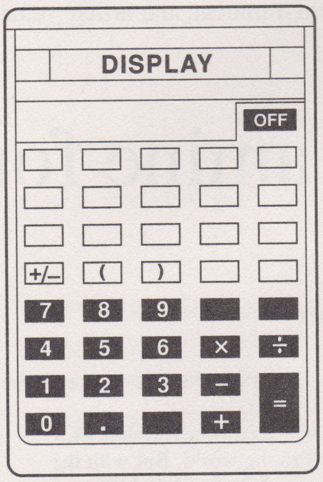


FIGURE 1 All calculators have the functions shown: divide, multiply, subtract, add and equals. In addition they all have a decimal point key. The +/– sign and brackets may be in other positions on your calculator. Please note that some calculators have different symbols from the ones shown above, e.g. * is the same as ×, / is the same as ÷ and ± is the same as +/–.

6.1 BUYING A CALCULATOR

What type of calculator should you buy? You need what most shops describe as a *scientific calculator*. *Casio* and *Sharp* are examples of suitable makes.

All the functions shown in Figure 1 will be used in Module 1. However, it is important to get a calculator that has the additional functions needed in later Modules. Your calculator must be capable of performing the following operations:

- square roots
- trigonometric functions (sin, cos, tan and their inverses)
- finding the reciprocal of any number ($1/x$)
- raising a number to a power (x^2, x^y or y^x)
- raising the number 10 to any power (10^x, EXP or EE)
- pi (π)
- memory, store and recall.

Don't be daunted by this list of more complex operations; you won't use them in Module 1!

6.2 USING YOUR CALCULATOR

Now you have bought your calculator, how do you use it? You could, of course, read the manufacturer's handbook and work it out as you go. To help you get used to working with a calculator we will give you directions on what to do as you progress through the Modules. Unless you do something very peculiar, such as pressing several keys at once or physically ill-treating it, it is just about impossible to damage a calculator.

You may want to read through the manufacturer's handbook.

In essence, to do a calculation you enter the figures and press the 'mathematical operations' keys, such as plus (+) and multiply (×) in the order in which they are given in the calculation. Each time you encounter a *new* type of calculation in the course you will find instructions about which keys to press and the order in which to press them presented in a box in the margin.

The Guided Exercises that follow show you how to use your calculator to add, subtract, multiply and divide whole numbers.

GUIDED EXERCISE 1: ADDING NUMBERS ON A CALCULATOR

Let us start with a straightforward addition: two plus (or add) eight equals ten. Put another way, 2 + 8 = 10. This 'statement of arithmetical truth' is called an **equation.** This word means that the assembly of things on the left hand side of the equals sign, 2 + 8 in this case, is exactly *equal* to the assembly of things on the right of the equals (=) sign—10 in this case.

BOX 1

Press	2	
press	+	
press	8	
press the	=	(10 should appear in display window)

Now let's try to do this addition using the calculator. Can you make the calculator give you the correct answer? Press the keys shown in Box 1 in the sequence it tells you to—and check that you get the right answer.

Now choose the correct buttons and test out 2 + 7 = 9 for yourself.

Keep practising until you feel quite confident about using the calculator to add numbers in this way.

GUIDED EXERCISE 2: SUBTRACTING NUMBERS ON A CALCULATOR

Try seven minus two equals five. The equation for this statement is :

$$7 - 2 = 5$$

Follow the instructions in Box 2 to do this on your calculator.

BOX 2

Press	7	
press	−	
press	2	
press	=	(5 should appear in the display window)

GUIDED EXERCISE 3: ADDING OR SUBTRACTING A SEQUENCE OF NUMBERS ON YOUR CALCULATOR

Sometimes you may want to add a whole series of numbers together. For example, imagine that you are carrying out an experiment in which you have to sieve some sandy gravel. You are left with 12 grams (12 g is the abbreviation) of fine sand, 10 g of coarse sand and 7 g of pebbles. Use the calculator to find the total number of grams of sandy gravel by following the instructions in Box 3.

BOX 3

Press	1	
press	2	
press	+	
press	1	
press	0	
press	+	
press	7	
press	=	(29 should appear in the display window)

Notice that you did not press = until you were ready for the final answer. The same applies to sequential subtraction, for example:

$$20 - 3 - 4 - 7 = 6$$

GUIDED EXERCISE 4: MULTIPLYING AND DIVIDING NUMBERS ON YOUR CALCULATOR

Try multiplying three by four to get twelve. First write it as an equation, then follow the sequence in Box 4:

$$3 \times 4 = 12$$

BOX 4

Press	3	
press	×	
press	4	
press	=	(12 should appear in the display window)

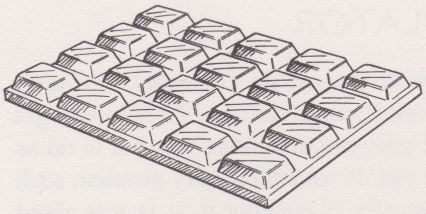


FIGURE 2 This chocolate bar is easily divided into five strips of four pieces.

Try the following division for yourself: twenty divided by five equals four. The equation is:

$$20 \div 5 = 4$$

If you are apprehensive about division, try 'chocolate bar thinking'. If you divide up a slab of 20 small squares between 5 children, each child will get 4 squares. Look at Figure 2 to picture this.

To do the calculation, press the buttons shown in Box 5.

BOX 5		
Press	20	
press	÷	
press	5	
press	=	(4 should appear in the display window)

Now try SAQs 2 to 4, which will give you some more practice in adding, subtracting, multiplying and dividing.

SAQ 2 Use your calculator to do the following:

(a) $130 \times 20 = ?$ (b) $16 + 24 = ?$ (c) $9 + 111 + 2 + 3 = ?$

(d) $35 - 15 = ?$ (e) $35 - 15 - 12 = ?$ (f) $1\,001 \times 2 = ?$

Note that when there are more than three figures in a number it is conventional to group them in threes, starting from the right as shown in (f) of SAQ 2 and (c) and (f) of SAQ 3. A similar convention is to put a comma instead of a space e.g. 1,001. This Course and the *Science Foundation Course* use spaces instead of commas.

SAQ 3 Use your calculator to do the following:

(a) $490 \div 10 = ?$ (b) $180 \div 3 = ?$ (c) $12\,532 \div 964 = ?$

(d) $132 \div 12 = ?$ (e) $101 \times 10 = ?$ (f) $1\,327 \times 64 = ?$

SAQ 4 Before you try the following question, remember that fairly easy arithmetic can be dressed up in a lot of words and other non-mathematical but quite complicated ideas. The following calculation involves one multiplying step and then one division step. The hard part is finding out from all the words *what it is* that you've got to multiply and divide! If you can't do it, look at the answer and try to work out why the answer is what it is.

As a person sleeps, air is drawn in and out of the lungs by the normal action of breathing. A little of the oxygen from that air passes from the lungs into the person's blood. Using appropriate apparatus, a research worker finds that a total volume of 9 litres of oxygen is absorbed by the blood in one hour. Given that there are 1 000 cubic centimetres (written as cm^3) in 1 litre, how many cubic centimetres are absorbed per minute?

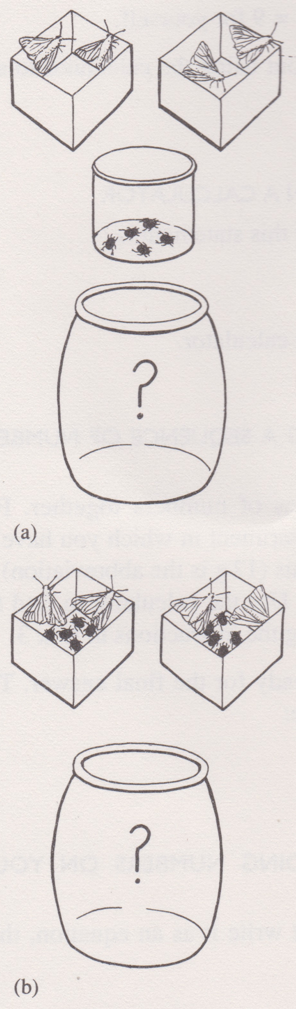


FIGURE 3 Two different collections of insects.

6.3 DOING ARITHMETIC IN THE RIGHT ORDER

All the calculations you have done so far have involved just one kind of mathematical operation. Either you've added things *or* multiplied them *or* divided them … and so on. You have not yet mixed the different kinds of operations in one equation—or one 'go' on the calculator. Often real scientific problems lead to equations that can only be worked out by doing more than one kind of operation.

Think about this arithmetic problem:

☐ A biologist puts five beetles into a jar. Another biologist collects two moths into a box and someone else collects two further moths into yet another box. Both boxes are emptied into the jar. How many insects are there in the jar? (Do the calculation in your head, using Figure 3a to help you if necessary. Do not use your calculator at this stage).

■ Beetles and moths are both insects, so there is no trick here! From the Figure, you can see the answer is *nine insects*—that is, *two lots of two* and another *five*.

Now try this slightly different arithmetic problem:

□ A biologist collects five beetles and two moths and puts them in a box. Another biologist does exactly the same using another box. Both boxes are later emptied into a jar. How many insects are there in the jar? (Do the calculation in your head, using Figure 3b to help you if necessary. Do not use your calculator at this stage).

■ Once again, from the Figure, you can see the answer is *fourteen insects*—that is, *two boxes* each containing *five plus two*.

Instead of just using the diagrams to work out the answers, let's write down arithmetical equations for these two problems and then use a calculator. To do this, you have to 'think your way' from the words of the problem to an arithmetical equation.

In the *first* situation, there are *two lots of two* (the two boxes of two moths) which are to be added to the five beetles. That is, 2×2 (which equals 4) is added to 5 to give the answer of 9. By convention—and that means by common agreement between mathematicians—this equation is:

$$2 \times 2 + 5 = 9$$

You do this equation by following a rule that is used by all mathematicians everywhere:

DO THE MULTIPLYING BEFORE THE ADDING.

Note that $5 + 2 \times 2$ has exactly the same meaning. The order doesn't affect the sense. If you press 5, then +, then 2, then ×, then 2, then =, you will once again get 9. The calculator knows the rules whatever order you enter your figures[1]! It will do the multiplying before the adding.

In the *second* situation, 5 (beetles) is *first* added to 2 (moths). This gives 7. And *then* the result of the addition is *multiplied* by 2 because there are two boxes. According to the rules that all mathematicians follow, if you want to do the adding before multiplying, then you put *brackets* around the bit to be added first. Thus the equation is:

$$(5 + 2) \times 2 = 14$$

The brackets change the order of doing the calculation; you do what is inside the brackets before multiplying. Now look at Boxes 6a and 6b which show you how to work out these two equations on a calculator.

You have had a rule about + and × and brackets, but what about − and ÷? And what about problems that introduce a fraction such as 'half' or 'a quarter', such as in 'half of the insects were put in a box'? There is an easy way to remember what order in which to do things. The rules are neatly summed up in the mnemonic[2] **BODMAS**.

BOX 6a

Your calculator knows the rules. So, for $2 \times 2 + 5 = 9$ all you have to do is to press these keys.

Press	2	
press	×	
press	2	
press	+	
press	5	
press	=	(9 should appear in the display window)

BOX 6b

Once again, your calculator knows the rules, so long as you tell it what to do in the proper mathematical way. So, for $(5 + 2) \times 2 = 14$, all you have to do is press the keys:

Press	(
press	5
press	+
press	2
press	)

At this point, without pressing anything else, the display will show 7. This is the result of adding 5 and 2. Now continue ...

press	×	
press	2	
press	=	(14 should appear in the display window)

---

[1] Some older calculators calculate in the order entered and fail to apply the rules. Provided you use a recent scientific calculator, you should have no difficulty. If you have an older calculator, check it!

[2] A **mnemonic** (pronounced nem-on-ic) is a set of letters that make up some memorable word or name that helps you remember the correct order of a number of things. For example, the 'American name' ROY G. BIV tells you the order of colours in a rainbow: red, orange, yellow, green, blue, indigo and violet.

The B of BODMAS stands for **B**rackets

The O of BODMAS stands for **O**f

The D of BODMAS stands for **D**ivide

The M of BODMAS stands for **M**ultiply

The A of BODMAS stands for **A**dd

The S of BODMAS stands for **S**ubtract

Where more than one of these operations occur in an equation, the order of letters in BODMAS tells you the order in which you must do things. Once you believe and accept the ideas behind the 'BODMAS' rules, you do not need to think about it in any great detail. Whenever you are faced with an equation properly written out with numbers, mathematical signs, brackets and so on, all you need do is to enter it into your calculator in the order you read it. The reason for this is that your calculator 'knows' the BODMAS rules and will apply them correctly for you. The more complicated bit is turning a problem in words (as with the beetles and moths, for example) into a correct equation—and the ability to do that comes with practice.

One final and slightly awkward point relates to the 'optional' use of brackets. The following examples explain what is meant by this.

Consider the equation $12 \div 3 \times 2 = ?$ According to BODMAS, you divide before you multiply. So, $12 \div 3 = 4$ and then $4 \times 2 = 8$. Thus, the correct answer is 8. A good modern calculator *should* give this answer if you simply enter:

$\boxed{1}\ \boxed{2}\ \boxed{\div}\ \boxed{3}\ \boxed{\times}\ \boxed{2}\ \boxed{=}$

Try it on yours. Do you get 8? You should, providing your calculator's electronics have BODMAS properly built in! Note that you do not need to enter any brackets.

Now think about another equation $12 \div (3 \times 2) = ?$ Here the brackets are telling you that (3×2) must be done before anything else: $3 \times 2 = 6$, then $12 \div 6 = 2$. The correct answer is 2. To do this on your calculator you *must* enter the brackets as shown, namely:

$\boxed{1}\ \boxed{2}\ \boxed{\div}\ \boxed{(}\ \boxed{3}\ \boxed{\times}\ \boxed{2}\ \boxed{)}\ \boxed{=}$

The brackets are essential.

So, what are 'optional brackets'? Some people find that unbracketed problems that depend solely on the rule 'division before multiply' are hard to cope with. They prefer to add brackets that simply *make it look clearer* even though the brackets are not strictly necessary. That is, they choose to write $(12 \div 3) \times 2 = 8$. Doing this on your calculator works perfectly well: the extra brackets simply 'reinforce' the BODMAS rule. If it helps you to put in 'optional brackets'—that's fine! Use optional brackets for clarity if you wish.

Now try SAQs 5–8

SAQ 5 Use your calculator to do the following:

(a) $3 \times 6 + 3 = ?$	(b) $16 + 24 \times 2 = ?$	(c) $35 - 5 \times 2 = ?$
(d) $3 \times (6 + 3) = ?$	(e) $16 \times 2 + 24 = ?$	(f) $(35 - 5) \times 2 = ?$

Before you do SAQ 6 you need to note the following. The multiplying sign is often left out in mathematics; thus $6 \times (1 + 2)$ is more normally written as $6(1 + 2)$. The occurrence of a number immediately next to a bracket tells you to multiply the result of 'doing the bracket' by that number. Most calculators do not 'know' this convention so you will probably need to re-insert the $\times$ sign as you enter it: $6 \times (1 + 2)$ not $6(1 + 2)$. Check your own calculator carefully.

SAQ 6 Use your calculator to do the following:

(a) $3(6 + 3) = ?$ (b) $16(2 + 24) = ?$ (c) $2(35 - 5) = ?$

SAQ 7 Use your calculator to do the following:

(a) $120 \div 10 + 1 = ?$ (b) $121 \div (10 + 1) = ?$ (c) $(35 - 5) \div 2 = ?$

(d) $180 \div 10 \times 2 = ?$ (e) $180 \div (10 \times 2) = ?$ (f) $(180 \div 10) \times 2 = ?$

SAQ 8

(a) A farmer's flock of one hundred sheep doubles over a period of time. His uncle then gives him sixty-five more sheep. Write an equation showing how many sheep he now has. Now solve (= 'work out') that equation using your calculator and write down how many sheep he now has altogether.

(b) Three children each have ten test tubes. The first breaks two, the second loses two and the third child gives two to her teacher. Write an equation showing the total number of tubes that remain and solve the equation using your calculator.

7 DECIMALS

Science—and, indeed, everyday life—is frequently concerned with numbers that are not whole numbers. Examples are three and one half ($3\frac{1}{2}$) metres, or 6.5 grams. Thus, we need to pay attention to both fractions and decimals. Of these, **decimals** are particularly important as calculators depend on decimals in any calculation not involving whole numbers.

Module 1 has already used a decimal—slipped in without comment in Section 1! The population of the world, the text said, is now 5.5 thousand million people; 5.5 is a decimal number. Decimals are used throughout science and you need to become fluent in adding, subtracting, multiplying and dividing them. Numbers consisting of two parts separated by what looks like a full stop are called *decimal numbers*. A 'full stop' used like this is called a 'decimal point'. Table 3 gives a few examples and describes how you should pronounce them. Incidentally, when mastering new ideas many people find that actually knowing how to pronounce the new terms that they come across can help to build up their confidence. This works as well for mathematics as it does for chemistry, biology, physics and Earth science, the various branches of science that occur in these Modules and in the *Science Foundation Course*.

TABLE 3 Some decimals and how to say them. Note that they are arranged in increasing order of size as you go down the column.

Decimal	Pronounced as …
0.5	nought point five
1.0	one point nought
1.2	one point two
5.5	five point five
10.65	ten point six five (*never* say ten point sixty-five!)
100.6	one hundred point six
201.259	two hundred and one point two five nine
4 236.748	four thousand two hundred and thirty six point seven four eight

What do numbers written in this way mean and why are they so important? In simple terms, decimals are a very convenient and easy way of expressing

numbers that are not whole numbers. Moreover, all calculations carried out with your calculator will be done, and displayed by the calculator, in terms of decimals. The following straightforward exercise illustrates this.

Suppose you buy a bar of fudge eleven centimetres (11 cm) long and share it equally between two children. If you were able to break it exactly in two, the length of each part would be five and a half centimetres. In decimals, however, the length is described as 5.5 cm. 'Five point five' *means exactly the same as* 'five and a half'. Suppose you had wished to divide the original bar equally between four children. The length of each piece would be:

$11 \div 4$

If you do this calculation using fractions, you will get two and three-quarters as your answer. However, if you do it on your calculator in the way you learned in Section 6, you will get 2.75. Check this for yourself. Once again, the important point is that the decimal 2.75 means the same as two and three-quarters. Table 4 summarizes the relationship between some common fractions and their decimal equivalent. *Remember*—these can be checked with a few quick presses of your calculator buttons!

TABLE 4 Some fractions and their decimals. Note that, reading down each column, they are arranged in order of increasing size.

Fraction	Decimal	Fraction	Decimal
one-hundredth	0.01	three-tenths	0.3
one-tenth	0.1	one-half	0.5
one-eighth	0.125	three-quarters	0.75
one-quarter	0.25	nine-tenths	0.9

Let us look in more detail at the parts making up decimal numbers. As you saw in the examples about fudge, many numbers that contain a decimal point are larger than one: the numbers 5.5 and 2.75 were used in the examples. Each consists of a whole number (the digits to the left of the decimal point) and a decimal part (the digits to the right of the decimal point). In numbers like 0.25 and 0.5, the part to the left of the point is nought. Once you are clear about these ideas (summarized in Figure 4), you can ignore the detailed relationship between fractions and decimals. Although it is clear that 0.5 is a half, the fact that one sixty-fourth is 0.015 625 is not very important.

$$\overbrace{54}^{\text{whole number}}.\overbrace{125}^{\text{decimal part}} \qquad\qquad \overbrace{0}^{\text{no whole number}}.\overbrace{69}^{\text{decimal part}}$$

FIGURE 4 Two decimal numbers: 54.125 and 0.69

You can see from Figure 4 that any number of digits can occur to the right of the decimal point, just as any number of digits can occur to the left. In terms of mathematics, 1 divided by 4 is *exactly* 0.25—the part on the right of the decimal point occupies exactly two places of decimals.

If, however, you attempted to divide one gram of salt into four 'equal' parts, you would not, in real terms, achieve an *exact division*. Depending on how accurate your balance was, you might record that each heap of salt contained 0.2 g or 0.24 g or 0.249 g or 0.249 5 g and so on.

The number of digits to the *right* of a decimal point in a decimal number is termed the *number of places of decimals*. The four values for the different

amounts of salt are expressed to different numbers of decimal places: 0.2 g is expressed to one decimal place; 0.24 is expressed to two decimal places; 0.249 is expressed to three decimal places; and 0.249 5 is expressed to four decimal places. The abbreviations 'dp' and 'dec.pl.' are sometimes used for 'decimal places'.

□ To how many decimal places is each of the two numbers in Figure 4 expressed?

■ 54.125 is expressed to three decimal places; 0.69 is expressed to two decimal places.

BOX 7

Press	2	
press	÷	
press	5	
press	=	(0.4 should appear on the display)

You can convert fractions to decimals using your calculator. First press the number at the top of the fraction; then press the divide key; then the number at the bottom of the fraction. Press equals, and the display will show the fraction as a decimal. Follow the instructions in Box 7 to convert the fraction two-fifths to a decimal number.

Now do SAQ 9 which will give you some practice in converting fractions to decimals.

SAQ 9 Convert the following fractions to decimals. Write down how many decimal places are displayed by your calculator in each case.

(a) one-tenth (b) one-third (c) three-eighths (d) one-hundredth.

Note that just as each digit to the *left* of the decimal point has a precise meaning (the units, tens, hundreds and thousands that you probably met in the past), so also does each digit to the *right* of the decimal point. Figure 5 illustrates this for the number 54.125

Tens	Units	Decimal point	Tenths	Hundredths	Thousandths
5	4	•	1	2	5

FIGURE 5 The decimal number 54.125. The left-hand part (54) consists of 5 tens and 4 units; the right-hand (decimal) part consists of 1 tenth, 2 hundredths and 5 thousandths.

BOX 8

Press	4	
press	+	
press	5	
press	•	(decimal point key)
press	5	
press	=	(9.5 should appear on the display)

The calculator procedure for adding, subtracting, multiplying and dividing decimals is exactly the same as that given for whole numbers in Section 5. This time, however, you make use of the *decimal point key*. Try the following calculation, following the instructions in Box 8:

$$4 + 5.5$$

You follow the same steps for subtraction. Try the following calculation for yourself:

$$9.5 - 5.5 = 4$$

When you enter 'nought point something' on your calculator—for example 0.5 or 0.165—you do *not* need to enter the 0 before you enter the decimal point. It is not actually *wrong* to press the 0 first; it is simply unnecessary and a waste of time. For example, in the calculation:

$$0.4 + 0.25$$

you would proceed as shown in Box 9.

BOX 9

Press	•	
press	4	
press	+	
press	•	
press	2	
press	5	
press	=	(0.65 should appear on the display)

Test yourself on the examples of decimal multiplication and division in the following questions, then try SAQs 10 to 12 for some further practice.

□ You read on a biscuit packet that each biscuit contains 1.24 g of fat. If there are 18 biscuits in the packet, how many grams of fat does the whole packet contain?

■ You arrive at the answer by multiplying 1.24 by 18 (22.32 should appear on the display). The whole packet therefore contains 22.32 g of fat.

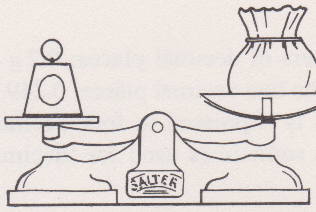


FIGURE 6 A set of kitchen scales.

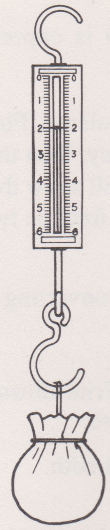


FIGURE 7 A spring balance.

□ Suppose the label says that the whole packet of biscuits contains 7.2 g of fibre. How much fibre does each biscuit contain?

■ This time you have to divide 7.2 by 18 (0.4 should appear on the display). Each biscuit therefore contains 0.4 g of fibre.

If you wished to know how much fibre there was in five and a half biscuits (i.e. 5.5) you would multiply 5.5 by 0.4 (the answer from the preceding calculation). In five and a half biscuits, therefore, there is a total of 2.2 g of fibre.

SAQ 10 Do the following calculations using your calculator:

(a) $16.2 + 3.6 = ?$	(b) $1.15 \times 100 = ?$	(c) $147.64 \times 3.7 = ?$
(d) $99.55 - 0.5 = ?$	(e) $11.5 \times 10 = ?$	(f) $46.555\,38 \div 3.6 = ?$

Note that when there are more than three figures to the *right* of the decimal point it is conventional to group these in threes, starting from the left as shown in SAQ 10(f).

SAQ 11 Every 100 g of yogurt contains 4 g of protein, 5.6 g of carbohydrate and 0.1 g of fat and the rest is water.

(a) How many grams of water are there in 100 g of yogurt?

(b) How many grams of carbohydrate are there in a tub containing 125 g of yogurt?

(c) How many grams of yogurt would contain 1 g of fat?

SAQ 12 Note that you need knowledge of the BODMAS rules and of decimals to do this SAQ. Note also that non-scientists would probably talk about 'the weight' of the children. This is scientifically incorrect usage, as the Box below explains. Note finally that a *kilo*gram is 1000 grams.

A rather heavy girl (of **mass** 72 kilograms) climbs on to a playground roundabout. Seven small boys also climb on to it. Three of them have identical masses of 28.5 kilograms and four of them have identical masses of 31.7 kilograms. Write an equation for the total mass of children on the roundabout. Work out their total mass in kilograms (abbreviated kg) using your calculator.

MASS AND WEIGHT

The mass of something is the total amount of substance in it—as measured on scales of the type used in many people's kitchens and illustrated in Figure 6.

The units used to measure mass are grams and kilograms (abbreviated to g and kg). The mass of something is a gauge of 'the amount of material in it'. There would be the 'same amount of you' if your mass was measured here or, if you were an astronaut, on the Moon where gravity is low.

The word 'weight' has a very precise meaning in science that is different in meaning from mass. Weight is measured in units that will not be discussed in this course. Weight is measured on spring balances of the type illustrated in Figure 7. On the low-gravity Moon, you would have much less weight than here on Earth.

Mass is used and referred to throughout this course. Weight—a quite complicated idea that is left to other courses—is not referred to again. So do not refer to or think of weight in the context of *Into Science*! Always, MASS.

8 NEGATIVE NUMBERS

BOX 10

Press 9

press –

press 10

press = (–1 should appear in the display)

All the numbers considered in the Module so far have been greater than 0 (greater than zero). This section discusses numbers that are less than zero.

On your calculator, subtract 10 from 9. You do this as shown in Box 10. The answer is -1. This is pronounced 'minus 1'. The idea of a negative number is probably not a strange one. If you have £9 in the bank and are permitted to write a cheque for £10, you have an overdraft of £1; that is, you now own 'minus one pounds'. Negative numbers often occur in science. For example, by tradition the freezing point of water is called 0°C. If you cool air down and down, it eventually becomes liquid at a temperature far below 0°C. In fact air liquefies at –183°C. This is pronounced 'minus 183 degrees Celsius' (or Centigrade, to use a more old fashioned term).

Later in the course you will learn to do more things with negative numbers. For now, you can probably see that adding a negative number to another negative number gives an even larger negative number. If you have an overdraft of ten pounds and then take over someone else's overdraft of a hundred pounds, your total debt is £110. So, $(-10) + (-100) = -110$. (Note that mathematicians use brackets to make it clear that negative numbers are being dealt with.)

Similarly, taking away a negative number is equivalent to adding the number! If I owe you £100 and have no other money, my total wealth is –£100. If you now are generous enough to let me off £60 of my debt to you, you have subtracted (taken away) part of my debt and all I now owe is £40. That is, my wealth is now –£40. What has happened can be written in mathematical terms as follows:

$$(-100) - (-60) = -40.$$

BOX 11

Press 100

press +/– (–100 should appear)

press – (the normal one!)

press 60

press +/– (–60 should appear)

press = (–40 should appear in the display)

Taking away some of my debt was equivalent to actually *giving* me £60. Thus, $(-100) - (-60)$ is equivalent to $(-100) + 60$ which equals -40. From this you can see that the rule is *minus a minus is a plus*.

To check this on your calculator, you first need to know how to enter negative numbers. To do this you *first* enter the number and *then* press +/– key shown in Figure 1. As noted in Figure 1, your calculator may have the +/– key in a different place from that shown in the Figure. Box 11 shows the steps for $(-100) - (-60) = -40$.

Multiplying a minus by a plus gives a minus (four lots of a hundred pound overdraft would, alas, amount to a four hundred pound overdraft). So, $(-100) \times 4 = -400$.

A minus multiplied by a minus is a plus. This may be hard to see. But a useful parallel is the 'double negative' in speech. If someone makes this error of speech and says 'I ain't got no money', it technically means the person *has got* some money because 'not none = some'! So, $-5 \times -6 = 30$. Finally, a minus divided by a minus is a plus e.g. $-200 \div -10 = 20$. This is entirely reasonable—how many 'mini-overdrafts' of ten pounds are then in a big overdraft of £200? Plainly 20 of them.

Summary of rules of negative numbers.

In each of the examples the number 3 is used, but it could, of course, be any number. (A positive number is not normally preceded by a + sign. It is included here for clarity.)

$(-3) + (-3) = -6$	$(-3) + (+3) = 0$
$(-3) - (-3) = 0$	$(-3) - (+3) = -6$
$(-3) \times (-3) = 9$	$(-3) \times (+3) = -9$
$(-3) \div (-3) = 1$	$(-3) \div (+3) = -1$

The rules of negative numbers are given in the marginal box. Try out the equations in this box on your calculator, then practise these ideas by doing SAQ 13.

Note that throughout the Course, any box with *thick black lines* contains material that summarizes important rules or definitions.

SAQ 13 Do the following calculations using your calculator:

(a) $-9 \times 8 = ?$	(b) $-50.5 \times -2.1 = ?$	(c) $-1 + -100 = ?$
(d) $-9 \times -8 = ?$	(e) $-11.5 \times 10 = ?$	(f) $-5 \div 2 = ?$

9 CONCLUSION

Before you leave this Module, think very carefully about the following points:

- How long did you spend on this Module? If it took you longer than about three hours, you might need to set aside longer periods of time for study than those set out in Table 1.
- Look back over the Module, and think about whether you would benefit from repeating one or more of the sections. The SAQs and the *Overview* should help you to decide about this.

To read effectively is a necessary skill in any branch of learning and being able to calculate is essential for science. The next Module looks at doing practical work. This introduces two other vital skills—those of observing and measuring.

10 OVERVIEW

SUMMARY

These are the concepts you have learnt about in this Module:

- Human population is very large and increasing rapidly.
- Human activity is damaging the environment.
- Mass is the amount of a substance measured on a set of scales. It is frequently measured in grams and kilograms.
- Volume is often measured in litres (l) or cubic centimetres (cm^3).

SKILLS

Now that you have completed this Module, you should begin to be able to:

- organize your study time
- use a variety of techniques to help make your reading more active
- use a calculator to add, subtract, multiply and divide whole numbers and decimals (including problems involving more than one of these operations within one equation)
- use decimals as a way of representing numbers that are not whole numbers
- express a decimal to a given number of decimal places
- write an arithmetical equation from a problem expressed in words
- deal with negative numbers in fairly simple problems.

APPENDIX 1: EXPLANATION OF TERMS USED

BILLION One thousand million: 1 000 000 000

BODMAS A mnemonic for remembering the order of doing mathematical processes in the same equation. **B**rackets, **O**f, **D**ivide, **M**ultiply, **A**dd, **S**ubtract.

DECIMAL A decimal is a fraction expressed by figures to the right of the unit number and separated from it by a decimal point—for example 2.345 These figures denote respectively so many tenths, hundredths, thousandths etc.

EQUATION An equation expresses equality between two separate parts on either side of an equals sign.

MASS The total amount of substance as measured on a set of scales. Commonly measured in units of gram (g) or kilogram (kg).

MNEMONIC A mnemonic is a word (or phrase) that is intended to help someone remember the correct order of a number of things. Examples are BODMAS (see above) and ROY G. BIV (the order of the colours of a rainbow).

ACKNOWLEDGEMENT

Grateful acknowledgement is made to the *Daily Telegraph* plc for the following material used in Module 1:

R. Highfield and A. Berry, 'Grim prophecy of ruinous famine for overloaded Earth'. *Daily Telegraph*, 27 August 1991.

EXERCISE COMMENTS

EXERCISE 1

Which do you think *you* will find difficult? Which will *you* find relatively easy? You may like to discuss your answer with other students at a tutorial.

EXERCISE 2

There is no right answer, of course. You may find much of this Module covers ground that you are totally familiar with. Even if that is the case, you can use it to familiarize yourself with the standard 'layout' of an *Into Science* Module. We expect from our experience of previous years that a good proportion of students will want to spend time on decimals. Negative numbers may also be a 'go slow' area.

Some people find they nearly always make wrong judgments about what they should read carefully. The techniques of *active reading* are often overlooked by some who could do with them!

EXERCISE 3

You might have chosen one or more of the following:

- scientific curiosity
- desire to be well-informed
- interest in the contribution of science to solving world problems.

EXERCISE 4

(i) The following are some important points that we selected from the Article. You may have had any of these, or perhaps others, in your list of three.

(a) the effect of a growing world population;

(b) the depletion of the Earth's resources;

(c) industrial pollution;

(d) global warming;

(e) ozone depletion;

(f) increased numbers of refugees;

(g) loss of biodiversity[1].

(ii) The misprint is in column 3. The number of refugees should read 14.5 million, not 14.5!

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[1] *Biodiversity* means the *range* of different types of plants, animals and other kinds of living organism found on Earth. Human activities cause many species, some of which might be important for ecological stability, to become extinct.

SAQ ANSWERS AND COMMENTS

SAQ 1 Only items 2 and 9 do *not* involve a pen or pencil! If you are content with the diagrams in the Module, item 7 could be 'just looking' rather than using a pencil. The key point is that to read actively, you mostly need to write or draw at the same time.

SAQ 2

(a) 2 600	(b) 40	(c) 125
(d) 20	(e) 8	(f) 2 002

SAQ 3

(a) 49	(b) 60	(c) 13
(d) 11	(e) 1 010	(f) 84 928

SAQ 4 150 cubic centimetres (cm^3) of oxygen are absorbed per minute.

If 1 litre equals 1 000 cm^3, then 9 litres equals 9 000 cm^3. There are 60 minutes in one hour, so you divide 9 000 by 60 to obtain the answer.

SAQ 5

(a) 21	(b) 64	(c) 25
(d) 27	(e) 56	(f) 60

SAQ 6

(a) 27	(b) 416	(c) 60

SAQ 7

(a) 13	(b) 11	(c) 15
(d) 36	(e) 9	(f) 36

Note that (f) is mathematically the same as (d). Optional brackets have been included to make it look clearer.

SAQ 8

(a) $2 \times 100 + 65$ = total number of sheep. This total (from your calculator) = 265

(b) $3(10 - 2)$ = number of test tubes remaining. You could also have written: $3 \times (10 - 2)$ or $(10 - 2)3$ or $(10 - 2) \times 3$ The total remaining (from your calculator) = 24

SAQ 9

(a) 0.1 (one decimal place)

(b) 0.333 333 333 (see below)

(c) 0.375 (three decimal places)

(d) 0.01 (two decimal places)

When one-third is expressed as a decimal as in (b), the figure 3 repeats itself indefinitely. The number of threes you actually see simply depends on the size of the display on your calculator. When this happens the figure is said to be 'recurring'. The answer to (b) is pronounced as 'nought point three recurring'.

SAQ 10

(a) 19.8	(b) 115	(c) 546.268
(d) 99.05	(e) 115	(f) 12.932 05

SAQ 11

(a) There is a total of 90.3 g of water in 100 g of yogurt.

To arrive at the answer, add together the values for protein, carbohydrate and fat:

$$4 + 5.6 + 0.1 = 9.7\text{ g}$$

Subtract 9.7 g from 100 g to get the amount of water.

(b) A tub containing 125 g of yogurt contains 7 g of carbohydrate.

In 100 g of yogurt there is a total of 5.6 g of carbohydrate. To find out how many grams of carbohydrate there are in 1 g of yogurt, divide 5.6 by 100:

$$5.6 \div 100 = 0.056\text{g}$$

To find out how many grams of carbohydrate there are in 125 g yogurt, multiply 0.056 by 125:

$$0.056 \times 125 = 7\text{g}$$

(c) 1000 g of yogurt contains 1 g of fat.

In 100 g there are 0.1 g of fat. 1 g of fat would therefore be contained in 100 divided by 0.1.

SAQ 12 Total mass of children:

$$= 72 + 3 \times 28.5 + 4 \times 31.7$$

Therefore, total mass of children = 284.3 kg.

SAQ 13

(a) −72	(b) 106.05	(c) −101
(d) 72	(e) −115	(f) −2.5